Digital Lock-in Amplifier

Synclock is a BC-based company specializing in designing and assembling semiconductors and electronic components. The company's newest product is a digital lock-in amplifier which is an electronic device used to extract weak signals from a noisy background. The primary client of the company is the Intelligent Sensing Laboratory based on SFU's Surrey campus. This product will be developed to satisfy our client's needs based on the scope mentioned below.

The Problem

Most lock-in amplifiers available on the market, whether analog or digital, lack certain features researchers desire. Traditional lock-in amplifiers lack portability, consume lots of power, are costly to purchase, and lack durability in different settings. Specifically, the signal-channel output for the reference signal cannot satisfy the client's needs, where the client wants to have two references out-of-phase at the same frequency with independently adjustable amplitudes. The two reference signals are used to eliminate the parasitic capacitance in the device-under-test. This, among other problems, including power consumption in the range of 40 Watts and a device weight of 6 kg, will lead to constraints that limit their research.

The Solution

Synclock manufactures a digital lock-in amplifier with remarkable features through innovative approaches. The amplifier is designed with a focus on portability, enabling researchers to carry it while maintaining top performance. By implementing advanced power management techniques, Synclock limits the device's power consumption to 1 Watt, ensuring extended battery life and reducing the need for charging. Through efficient manufacturing, component selection, and production methods, Synclock offers the lock-in amplifier at a competitive price point below $1000. Additionally, the amplifier provides flexibility in adjusting signal parameters, empowering researchers to tune measurements according to their needs. To ensure durability in diverse environments, Synclock incorporates a weather-resistant casing making the amplifier suitable for both field and laboratory settings. This approach delivers digital lock-in amplifiers that offer researchers an affordable, portable, power-efficient, and flexible solution without losing durability or performance.

The Scope

The final product will be a compact and portable device with a PCB size comparable to a regular breadboard. The device will feature a weatherproof casing and two bipolar 2-input ADCs, one for reference signal calibration and the other for signal input. With a 16-bit ADC sampling rate of 500 kHz, the device ensures high-precision data acquisition. Users will use the lock-in amplifier's constant-frequency mode for signals with known frequencies and the frequency sweep mode for signals with unknown frequencies. Additionally, users will have the flexibility to adjust the amplitudes of two independent reference signals. The acquired data will be stored on a laptop for further processing, while real-time UI plotting capabilities will enable users to visualize the data with constant-frequency and frequency sweep plots. Moreover, the device will include an adjustable digital low-pass filter at the output, allowing users to customize the corner frequency according to their needs.

Test Plan

This test plan covers six different aspects of the lock-in amplifier device testing, including ADC input ports, amplifiers' gain adjustability, digital lock-in logic, data storage, the constant frequency operating mode, and the frequency sweep mode. The test plan aims to verify the device's ability to accurately process and analyze input signals, maintain data integrity during transmission and storage, and provide reliable output representations. The tests shall be conducted in an electronic laboratory setting with access to a function generator and an oscilloscope.

1) Testing input ports: Connect a known signal source to the ADC input ports and verify the UI can plot the signal. Connect the reference signal, apply digital lock-in processing, and verify the amplitude.
2) Testing the amplifiers' gain adjustability: Apply a bipolar signal to the input and check if the signal becomes unipolar at the ADC pre-amplifier's output. Set the reference signals' gain via the user interface and check the DAC's output using an oscilloscope.
3) Testing the digital lock-in logic: Feed the device with input signals of known frequencies, vary the filter parameters via the user interface, and check that the filtered signal is expected and the filtering time is reasonable.
4) Testing data storage: Plug a USB cable into the device and confirm the transmitted data matches with the plotted data.
5) Testing the constant-frequency mode: Apply a signal with a known frequency to the input, vary the signal amplitude over time, and verify the UI plot reflects the changes in amplitude.
6) Testing the frequency-sweep mode: Apply a signal with an unknown frequency to the input, sweep the reference signal frequency to identify the input signal frequency, and check the result using an oscilloscope.

The Opportunity

Lock-in amplifier products have a relatively small market globally. They are highly specialized laboratory equipment used in research and development. In 2022, the market for lock-in amplifiers was estimated to be around $25.4 million, projected to reach $32.2 million by 2030. The digital compartment is estimated to hold two-thirds of the global market share by the end of the analysis period from 2022 to 2030. Synclock's digital lock-in amplifier is priced at $800 CAD per device. While aiming to sell 250 units annually across Canada by 2030, the company's annual gross sales are estimated at $0.2 million CAD, taking a 1% share of the global digital lock-in amplifier market.

Competitive Advantage

Synclock has been working with electronic components for a combined 10+ years with team members boasting a minimum of 5 years of industry experience. Our affordable digital lock-in amplifier introduces new features that address the shortcomings of existing lock-in amplifiers, positioning us one step ahead of the competition. As a company, we prioritize continuous innovation by investing in research and development to continue improving our products. Furthermore, having studied and tested available lock-in amplifiers to understand their current drawbacks, the company is fully aware of the components needed to develop an improved product for the Intelligent Sensing Laboratory. Finally, our client is willing to help in developing our product giving us an advantage over the rest of the market. Companies like Zurich Instruments do not receive the same mentorship and continue to produce lock-in amplifiers falling short of our improved features.

Financials

	M1	M2	M3	M4	M5	M6
NPY1	-$3,004	-$1,009	$587	-$115	$2,431	$1,880
NPY2	$11,800	$13,100	$12,450	$55,350	$13,750	$13,100

	M7	M8	M9	M10	M11	M12	FYT
NPY1	$1,378	$2,875	$26,830	$5,370	$6,074	$5,475	$48,772
NPY2	$16,350	$15,050	$20,300	$49,700	$12,600	$14,700	$297,022

The table above provides a summary of our net profit after two years, where the top row shows the first year and the bottom row shows the second year. As seen from the table, our net profits will gradually increase due to improved marketing leading to higher sales. For a comprehensive view, a complete table and a link to our spreadsheet are provided in Appendix C, offering a more detailed breakdown of our expenses and sales.

	1st Year End	2nd Year End
Total Current Assets	$118,247	$412,450
Total Fixed Assets	$20,000	$10,000
Total Assets	$138,247	$422,450
Total Liabilities	$29,000	$24,500
Total Equity	$109,247	$397,950
Liabilities + Equity	$138,247	$422,450

The summary table of our budget sheet is shown above. As indicated by the numbers, the sum of our liabilities and equity equals our total assets, confirming the accuracy of all our calculations. For a more in-depth breakdown of each category, you can find detailed numbers in Appendix C through a provided link, along with images of our comprehensive table.

The Team

The team consists of Ese Dan-Aighewi, Brayden McKeen, Haoran Zhou, Lucien Somorai, Minghui Liang, and Yupeng Zhao. As final-year engineering students, we have a wide range of experience and expertise, covering computer engineering, electronics engineering, and engineering physics. Within our group, three members specializing in computer engineering have experience with embedded system development, including programming microcontrollers and developing user interfaces. Additionally, one member with a background in electronics engineering is knowledgeable in PCB design from their previous PCB projects. The team is also

well-versed in digital signal processing techniques, which are extensively used in lock-in amplifier development.

The Client

Our client is Dr. Behraad Bahreyni, a professor at SFU's Surrey Campus for the Mechatronic Systems Engineering program. He is also the principal investigator of the Intelligent Sensing Laboratory. We are currently developing the lock-in amplifier for his laboratory based on the agreed-upon scope outlined above.

Ask

We are seeking $5,500 of funding which will be used for:

1) Material purchasing and prototype manufacturing (approximately $3,000)
2) Performing field tests and comparing with existing products (approximately $500)
3) Design modification and optimization (approximately $2,000)

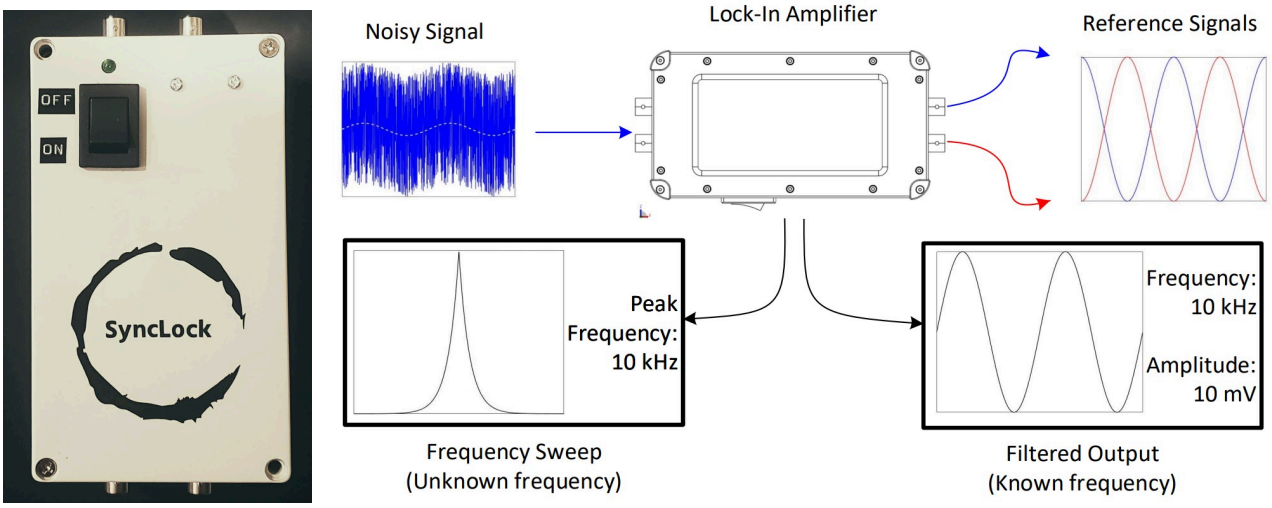
Demo Learning Outcome & Future Steps

The main learning outcome taken from the digital lock-in amplifier project demo is around the communication aspect and the user expectation. The user may not have a well understanding of the signal lock-in technique and may not know the operating modes of the device. Hence, it is important for the designers to specify the methodology with example cases to guide the user.

While the current form of the digital lock-in amplifier meets the main requirements provided by the client, enhancements and additional features can be incorporated in different aspects to improve the project's usability and performance.

- Hardware: Replace the amplifier's voltage reference with an active low-impedance reference to improve signal stability and gain-bandwidth product.
- Software (computing logic): Introduce a calibration routine to ensure reliability of the measurements over time.
- Software (user interface): Add the option to show the log-log scale for the frequency sweep mode plot; Remove the DC offset from the lock-in mode plot for consistent presentation.
- Product Package: Add a USB-C cable to the essential accessory list.
- Operational Manual: Provide example using and testing cases for users to follow and show intuitive results such that users know the correct data to look for. Also, add timing instructions so that users know how long to wait for the results to appear on the screen.

Graphical Abstract



Appendix A: Progress Review Meeting Minutes

Activity 4 – Progress Review Meeting

Meeting Date: June 16, 2023
Schedule: 12:00 pm to 12:40 pm
Start: 12:02 pm, End: 12:43 pm, Length: 41 minutes
Location: ASB, Room 8856

Attendees
Supervisors: Dr. Shervin Jannesar, Usman Ahmed
Members: Ese Dan-Aighewi Minghui Liang Brayden McKeen
Lucien Somorai Yupeng Zhao Haoran Zhou

Meeting Purpose: To discuss the current progress of the Digital Lock-In Amplifier (DLA) project. To refine all the tasks that should be completed after the meeting and also obtain feedback from the instructional team.

Agenda:

1. Address the changes needed to be made for activity 3
2. Show current progress on the project.
3. Discuss how to construct test plans for our project

Minutes:
Shervin called the meeting to order at 12:02 pm, and the team agreed to record the minutes.

- **Introduction (Shervin)**
  - Shervin began by saying how our progress was much better than in ENSC 405W after discussing with our client Behraad
  - He then went on to outline his expectations for the upcoming report and highlighted all the major changes required for activity 3 in the next report
    - This included the formatting changes we made and the graphical abstract
    - For the graphical abstract, he expects us to have a friend review it and understand what is going on
- **Questions and Discussion (All participants)**
  - Yupeng started by discussing the block diagram of our overall device and its functionality
  - The instructional team mentioned we need to add known and unknown signal descriptions to the scope of our report and we discussed the test plan.
  - Usman asked why we need an inverting and non-inverting reference input and Haoran responded that Dr. Bahreyni requested it because he wants to use the inverted reference signal to eliminate parasitic capacitance.
  - Brayden talked about the PCB design and footprint
    - The instructional team suggested we finish it by Monday and have it printed by next Friday
  - Ese and Yupeng then went on to show our current progress with a demo of how the UI is working with our new development board. A function generator was used to provide an

input signal to the UI, but the signal output was distorted due to poor signal transmission from the USB.
    - The instructional team suggested we need to find a casing asap, especially if we plan on 3D printing one
    - They also mentioned that we have 2 weeks to finish the project as it should be finished by the end of June
    - They will be contacting 2 members of the team to give a progress update in roughly 10 days.

Action Items:

- Address the comments made to activity 3 and the meeting in the next report (Assigned to SyncLock team, due 3 days after the meeting)
- Redo the graphical abstract making it easier for any person to view (Assigned to SyncLock team, due 3 days after the meeting)
- Submit the scope document on time. (Assigned to SyncLock team, due 3 days after the meeting)
- Start thinking about the user manual, it must have very clear instructions. (Assigned to SyncLock team)
- Finalize the PCB and get it printed by the end of next week (Assigned to SyncLock team)
- Order a casing for our device ASAP (Assigned to SyncLock team)
- The whole project shall be completed in 2 weeks (Assigned to SyncLock team)

The meeting was adjourned at 12:43 pm by Shervin.

Appendix B: Scope Meeting Minutes

Activity 3 – Refined Scope Meeting

Meeting Date: May 24, 2023
Schedule: 10:30 am to 11:00 am
Start: 10:28 am, End: 11:03 am, Length: 35 minutes
Location: ASB, Room 8856

Attendees
Supervisors: Dr. Shervin Jannesar, Usman Ahmed
Members: Ese Dan-Aighewi Minghui Liang Brayden McKeen
Lucien Somorai Yupeng Zhao Haoran Zhou

Meeting Purpose: To discuss the current prototype and scope of the Digital Lock-In Amplifier (DLA) project. To refine all the tasks that should be completed during the next 3 months and also get feedback from the instructional team.

Agenda:

1. Discuss the logistics of the project scope in the context of ENSC 440.
2. Show current progress on the project.
3. Emphasize work distribution and individual contribution among the group.

Minutes:
Shervin called the meeting to order at 10:28 am, and the team agreed to record the minutes.

- **Introduction (Yupeng)**
  - Yupeng gave a brief description of his role, the team, and what the project is all about.
- **Questions and Discussion (All participants)**
  - Shervin asked if the team has had a chance to play with the current DLA's in the Intelligent Sensing Lab, with Usman wondering if the team has been able to replicate its results. Ese and Yupeng responded that the team has used those DLA's but has not been able to fully replicate its results.
  - Shervin suggested that the team communicate properly with Behraad as he is a professional working with these types of devices and believes that this project is doable.
  - Questions were brought up about the current graphical abstract and Shervin and Usman provided tips on how to correct the mistakes made in activity 2: treat the system like a black box so that the overall functionality of the device is clear.
  - Yupeng gave a run-down of the team's current scope, delving into the specifics, however, Usman asked for a broader picture. The following points were then discussed:
    - § A full-functioning device must be completed at the end of the term.
    - § The PCB should be enclosed and be the size of a breadboard.
    - § A bipolar 2-input ADC, one designed for reference signal calibration and another designed for signal input, will be available on the device.
    - § 16-bit ADC sampling at the range of 500 kHz should be used.

- § Two reference signals with independently adjustable amplitudes should be present.
- § Realtime UI plotting, including a constant-frequency plot and a frequency sweep plot.
- § The satisfaction of the client is very important.

- Ese mentioned that Dr. Behraad is fine with removing the option of storing data on an SD card, so instead, the system will always have to be connected to a computer to collect data in real-time. Usman added that we must be able to at least store the data on the computer.
- Usman suggested that the team verify the limitations of the types of signals that the device can support.

Action Items:

- Think more in terms of the big picture and refine the scope of the document. (Assigned to SyncLock team, complete as soon as possible)
- Send an email to Dr. Behraad to verify the scope and follow up with him if a response is not received in time. (Assigned to SyncLock team, complete as soon as possible)
- Submit the scope document on time. (Assigned to SyncLock team, due 3 days after the meeting)
- Start thinking about the user manual, it must have very clear instructions. (Assigned to SyncLock team)
- Verify the limitations of the device. (Assigned to SyncLock team)
- Discuss each person's tasks for the project. (Assigned to SyncLock team)

The meeting was adjourned late at 11:03 am by Shervin.

Appendix C: Financial Documents

Service	Price
Installation (10 units or less)	$0
Monthly-Residentials	$0
Annual Residentials	$0
Monthly-Commercial	$0
Annual Commercial	$0
Unit cost	$1,050

	SyncLock					Last Updated:		30-Jun-23						
	Existing	Month #1	Month #2	Month #3	Month #4	Month #5	Month #6	Month #7	Month #8	Month #9	Month #10	Month #11	Month #12	FY Totals
SALES:														
Residential installations:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial installations:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Residentials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Commercials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Residentials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Commercials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Units Residential:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Units Commercial:	0	4	9	13	15	19	20	22	25	70	30	26	25	278
TOTAL UNITS:	0	4	9	13	15	19	20	22	25	70	30	26	25	278
TOTAL CONTRACTS:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVG. SELLING PRICE (CAD):	$999	$999	$999	$999	$999	$999	$999	$999	$999	$999	$999	$999	$999	
AVG. INSTALLATION PRICE (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. ANNUAL Res (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. ANNUAL Com (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. MONTHLY Res (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. MONTHLY Com (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
GROSS REVENUE (CAD):	$0	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974	$24,975	$277,722
COST OF GOODS SOLD:														
Unit costs:	$600	$600	$600	$600	$600	$550	$550	$500	$500	$450	$450	$400	$400	
AVG. Installation cost per unit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. Cost of Monthly inspection	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
TOTAL COGS:	$0	$2,400	$5,400	$7,800	$9,000	$10,450	$11,000	$11,000	$12,500	$31,500	$13,500	$10,400	$10,000	$134,950
GROSS MARGIN:	$0	$1,596	$3,591	$5,187	$5,985	$8,531	$8,980	$10,978	$12,475	$38,430	$16,470	$15,574	$14,975	$142,772
(%)		39.9%	39.9%	39.9%	39.9%	44.9%	44.9%	49.9%	49.9%	55.0%	55.0%	60.0%	60.0%	
EXPENSES:														
PERSONNEL														
Marketing & Sales:	$0	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800
CTO (R&D, Product development):	$0	$2,000	$2,000	$2,000	$2,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$500	$500	$15,000
CEO:	$0	$0	$0	$0	$1,000	$1,000	$2,000	$3,000	$3,000	$5,000	$5,000	$5,000	$5,000	$30,000
Executive Assistance/Book Keeper	$0	$500	$500	$500	$1,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$18,500
TOTAL PERSONNEL:	$0	$2,900	$2,900	$2,900	$4,400	$4,400	$5,400	$6,400	$6,400	$8,400	$8,400	$7,900	$7,900	$68,300
OFFICE EXPENSES:	$0	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$12,000
ACCOUNTING EXPENSES:	$0	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,200
LEGAL & PATENT EXPENSES:	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
OVERHEAD & UNEXPECTED:	$0	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000
LOAN INTEREST:	$0	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$0	$0	$1,000
LOAN PAYBACK:	$0	$0	$0	$0	$0	$0	$0	$1,500	$1,500	$1,500	$1,000	$0	$0	$5,500
TOTAL EXPENSES:	$0	$4,600	$4,600	$4,600	$6,100	$6,100	$7,100	$9,600	$9,600	$11,600	$11,100	$9,500	$9,500	$94,000
NET PROFIT (BT):	$0	-$3,004	-$1,009	$587	-$115	$2,431	$1,880	$1,378	$2,875	$26,830	$5,370	$6,074	$5,475	$48,772
(%)		-75.2%	-11.2%	4.5%	-0.8%	12.8%	9.4%	6.3%	11.5%	38.4%	17.9%	23.4%	21.9%	17.6%

	SyncLock					Last Updated:		30-Jun-23						
	Existing	Month #1	Month #2	Month #3	Month #4	Month #5	Month #6	Month #7	Month #8	Month #9	Month #10	Month #11	Month #12	FY Totals
SALES:														
Residential installations:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial installations:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Residentials (Including renewals):	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Commercials (Including renewals):	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Residentials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Commercials:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Units Residential:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Units Commercial:	278	30	32	31	97	33	32	37	35	40	82	29	32	788
TOTAL UNITS:	278	30	32	31	97	33	32	37	35	40	82	29	32	788
TOTAL CONTRACTS:	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVG. SELLING PRICE (CAD):	$999	$1,050	$1,050	$1,050	$1,050	$1,050	$1,050	$1,050	$1,050	$1,100	$1,100	$1,100	$1,100	
AVG. INSTALLATION PRICE (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. ANNUAL Res (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. ANNUAL Com (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. MONTHLY Res (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. MONTHLY Com (CAD):	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
GROSS REVENUE (CAD):	$277,722	$31,500	$33,600	$32,550	$101,850	$34,650	$33,600	$38,850	$36,750	$44,000	$90,200	$31,900	$35,200	$822,372
COST OF GOODS SOLD:														
Unit costs:	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	
AVG. Installation cost per unit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
AVG. Cost of Monthly inspection	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
TOTAL COGS:	$134,950	$12,000	$12,800	$12,400	$38,800	$13,200	$12,800	$14,800	$14,000	$16,000	$32,800	$11,600	$12,800	$338,950
GROSS MARGIN:	$142,772	$19,500	$20,800	$20,150	$63,050	$21,450	$20,800	$24,050	$22,750	$28,000	$57,400	$20,300	$22,400	$483,422
(%)		61.9%	61.9%	61.9%	61.9%	61.9%	61.9%	61.9%	61.9%	63.6%	63.6%	63.6%	63.6%	
EXPENSES:														
PERSONNEL														
Marketing & Sales:	$4,800	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$8,400
CTO (R&D, Product development):	$15,000	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800	$24,600
CEO:	$30,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$66,000
Executive Assistance/Book Keeper	$18,500	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$42,500
TOTAL PERSONNEL:	$68,300	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$6,100	$141,500
OFFICE EXPENSES:	$12,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$24,000
ACCOUNTING EXPENSES:	$1,200	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$2,400
LEGAL & PATENT EXPENSES:	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
OVERHEAD & UNEXPECTED:	$6,000	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$12,000
LOAN INTEREST:	$1,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,000
LOAN PAYBACK:	$5,500	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,500
TOTAL EXPENSES:	$94,000	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$186,400
NET PROFIT (BT):	$48,772	$11,800	$13,100	$12,450	$55,350	$13,750	$13,100	$16,350	$15,050	$20,300	$49,700	$12,600	$14,700	$297,022
(%)		37.5%	39.0%	38.2%	54.3%	39.7%	39.0%	42.1%	41.0%	46.1%	55.1%	39.5%	41.8%	36.1%

Gross Revenue	$0	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974

	Month #1	Month #2	Month #3	Month #4	Month #5	Month #6	Month #7	Month #8	Month #9	Month #10	Month #11	Month #12
CASH FLOW 1st Year (CAD):												
Open Cash Balance:	$15,000	$18,996	$20,987	$23,974	$26,559	$30,440	$33,870	$37,748	$42,123	$89,953	$76,823	$78,197
Add Cash from Sales:	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974	$24,975
Less Cash re Expenses:	$0	-$4,600	-$4,600	-$4,600	-$6,100	-$6,100	-$7,100	-$9,600	-$9,600	-$11,600	-$11,100	-$9,500
Less Cash for Prod'n:	$0	-$2,400	-$5,400	-$7,800	-$9,000	-$10,450	-$11,000	-$11,000	-$12,500	-$31,500	-$13,500	-$10,400
Closing Cash Balance:	$18,996	$20,987	$23,974	$26,559	$30,440	$33,870	$37,748	$42,123	$89,953	$76,823	$78,197	$83,272
ACCOUNTS RECEIVABLE:												
Open A/R Balance:	$0	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974
+ New Sales:	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974	$24,975
- Cash From Sales:	$0	-$3,996	-$8,991	-$12,987	-$14,985	-$18,981	-$19,980	-$21,978	-$24,975	-$69,930	-$29,970	-$25,974
= Closing A/R Balance:	$3,996	$8,991	$12,987	$14,985	$18,981	$19,980	$21,978	$24,975	$69,930	$29,970	$25,974	$24,975
ACCOUNTS PAYABLE:												
Open A/P Balance:	$0	$7,000	$10,000	$12,400	$15,100	$16,550	$18,100	$20,600	$22,100	$43,100	$24,600	$19,900
+ Prod'n goods rec'd:	$2,400	$5,400	$7,800	$9,000	$10,450	$11,000	$11,000	$12,500	$31,500	$13,500	$10,400	$10,000
+ Expense items:	$4,600	$4,600	$4,600	$6,100	$6,100	$7,100	$9,600	$9,600	$11,600	$11,100	$9,500	$9,500
- Goods shipped:	$0	-$2,400	-$5,400	-$7,800	-$9,000	-$10,450	-$11,000	-$11,000	-$12,500	-$31,500	-$13,500	-$10,400
- Expense Items Paid:	$0	-$4,600	-$4,600	-$4,600	-$6,100	-$6,100	-$7,100	-$9,600	-$9,600	-$11,600	-$11,100	-$9,500
= Closing A/P Balance:	$7,000	$10,000	$12,400	$15,100	$16,550	$18,100	$20,600	$22,100	$43,100	$24,600	$19,900	$19,500
INVENTORY:												
Open Inventory:	$0	$2,400	$5,400	$7,800	$9,000	$10,450	$11,000	$11,000	$12,500	$31,500	$13,500	$10,400
+ Prod'n goods rec'd:	$2,400	$5,400	$7,800	$9,000	$10,450	$11,000	$11,000	$12,500	$31,500	$13,500	$10,400	$10,000
- Goods shipped:	$0	-$2,400	-$5,400	-$7,800	-$9,000	-$10,450	-$11,000	-$11,000	-$12,500	-$31,500	-$13,500	-$10,400
= Closing Inventory Balance:	$2,400	$5,400	$7,800	$9,000	$10,450	$11,000	$11,000	$12,500	$31,500	$13,500	$10,400	$10,000

	Month #1	Month #2	Month #3	Month #4	Month #5	Month #6	Month #7	Month #8	Month #9	Month #10	Month #11	Month #12
CASH FLOW 2nd Year (CAD):												
Open Cash Balance:	$83,272	$95,272	$109,172	$121,222	$202,972	$191,122	$203,822	$222,172	$236,422	$258,722	$325,222	$316,622
Add Cash from Sales:	$31,500	$33,600	$32,550	$101,850	$34,650	$33,600	$38,850	$36,750	$44,000	$90,200	$31,900	$35,200
Less Cash re Expenses:	-$9,500	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700
Less Cash for Prod'n:	-$10,000	-$12,000	-$12,800	-$12,400	-$38,800	-$13,200	-$12,800	-$14,800	-$14,000	-$16,000	-$32,800	-$11,600
Closing Cash Balance:	$95,272	$109,172	$121,222	$202,972	$191,122	$203,822	$222,172	$236,422	$258,722	$325,222	$316,622	$332,522
ACCOUNTS RECEIVABLE:												
Open A/R Balance:	$24,975	$31,500	$35,130	$35,712	$106,593	$44,340	$44,973	$51,855	$51,642	$60,677	$110,917	$60,899
+ New Sales:	$31,500	$33,600	$32,550	$101,850	$34,650	$33,600	$38,850	$36,750	$44,000	$90,200	$31,900	$35,200
- Cash From Sales:	-$24,975	-$29,970	-$31,968	-$30,969	-$96,903	-$32,967	-$31,968	-$36,963	-$34,965	-$39,960	-$81,918	-$28,971
= Closing A/R Balance:	$31,500	$35,130	$35,712	$106,593	$44,340	$44,973	$51,855	$51,642	$60,677	$110,917	$60,899	$67,128
ACCOUNTS PAYABLE:												
Open A/P Balance:	$19,500	$19,700	$20,500	$20,100	$46,500	$20,900	$20,500	$22,500	$21,700	$23,700	$40,500	$19,300
+ Prod'n goods rec'd:	$12,000	$12,800	$12,400	$38,800	$13,200	$12,800	$14,800	$14,000	$16,000	$32,800	$11,600	$12,800
+ Expense items:	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700	$7,700
- Goods shipped:	-$10,000	-$12,000	-$12,800	-$12,400	-$38,800	-$13,200	-$12,800	-$14,800	-$14,000	-$16,000	-$32,800	-$11,600
- Expense Items Paid:	-$9,500	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700	-$7,700
= Closing A/P Balance:	$19,700	$20,500	$20,100	$46,500	$20,900	$20,500	$22,500	$21,700	$23,700	$40,500	$19,300	$20,500
INVENTORY:												
Open Inventory:	$10,000	$12,000	$12,800	$12,400	$38,800	$13,200	$12,800	$14,800	$14,000	$16,000	$32,800	$11,600
+ Prod'n goods rec'd:	$12,000	$12,800	$12,400	$38,800	$13,200	$12,800	$14,800	$14,000	$16,000	$32,800	$11,600	$12,800
- Goods shipped:	-$10,000	-$12,000	-$12,800	-$12,400	-$38,800	-$13,200	-$12,800	-$14,800	-$14,000	-$16,000	-$32,800	-$11,600
= Closing Inventory Balance:	$12,000	$12,800	$12,400	$38,800	$13,200	$12,800	$14,800	$14,000	$16,000	$32,800	$11,600	$12,800

BALANCE SHEET

	As at:		
	Year Beginning	**1st Year End**	**2nd Year End**
ASSETS			
Cash:	$15,000	$ 83,272	$332,522
Inventory:		$ 10,000	$12,800
Accounts Receivable:		$ 24,975	$67,128
TOTAL CURRENT ASSETS:	$15,000	$ 118,247	$ 412,450
Intellectual Property:	15000	$ 20,000	$ 10,000
TOTAL FIXED ASSETS:	15000	$ 20,000	$ 10,000
TOTAL ASSETS:	$30,000	$ 138,247	$ 422,450
LIABILITIES			
Bank Line:	15000	$ 9,500	$ 4,000
Accounts Payable:	0	$ 19,500	$20,500
Long Term Debts:			
TOTAL LIABILITIES:	15000	$ 29,000	$ 24,500
SHAREHOLDERS' EQUITY:			
Share Capital:	15000	$ 50,475	$ 90,928
Retained Earnings:		$ 48,772	$ 297,022
Bank credit:		$ 10,000	$ 10,000
TOTAL EQUITY:	15000	$ 109,247	$ 397,950
LIABILITIES + EQUITY:	30000	$ 138,247	$ 422,450

Spreadsheet link: Activity 6-Team 8.xlsx